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ABSTRACT

Three models are examined in terms of their historical growth, structural similarities and differences, and their implementation and use. They are CAMPUS (Comprehensive Analytical Methods of Planning in University Systems), RRPM (Resource Requirements Prediction Model), and HIS (Hochschule Information System). Their basic logics are explained with respect to level of detail and planning variables. Student flow modules, non-salary costs, and general costing are considered. Differences are cited among dimensions, revenue model, capital budget, output reports, capacity module, and development and implementation costs. Other planning modules are mentioned: CAP:SC/SEARCH, HELP/PLANTRAN, and TUSS. From the viewpoint of helping the user implement and use the model, none of the models provide help in formulating the support (non-salary) cost equations nor in calculating the cost coeffecients. The models also do not help the use to calculate trade-offs directly. (LBH)

PROGRAMME ON INSTITUTIONAL MANAGEMENT IN HIGHER EDUCATION

PROGRAMME SUR LA GESTION DES ÉTABLISSEMENTS D'ENSEIGNEMENT SUPÉRIEUR

INSTITUTIONAL PLANNING MODELS IN HIGHER EDUCATION

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I.

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Institutional Planning Models in Higher Education

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I.

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INSTITUTIONAL PLANNING MODELS IN HIGHER EDUCATION

1. Introduction

Use of formal planning models is a relatively recent development for higher education. A survey done in 1970 (Weathersby and Weinstein 1970)(1) identified 31 such models. Of these eight were resource allocation models and only two of these were operational. They were CAMPUS V (Judy & Levine, 1965) and CSM (Weathersby 1967). Since then there has been considerable activity in planning models and in the use of programme planning and budgeting (Balderston and Weathersby, 1972, Weathersby and Balderston, 1972, also Farmer, 1970). CAMPUS has been reprogrammed and now appears in many different versions: CSM has been the main basis of the development of a set of models called RRPM: while other models in development during the 1960s have now become operational. Of all these models developed in America there are two that are generalised enough to be of great interest for the European audience of this monograph. These models are CAMPUS the most comprehensive and detailed; and RRPM that is the most accessible and commonly used. In addition there is the HIS model /Busch, 1972, Dettweiler and Frey 1972 (a) and (b)/ which is the most implemented model in Europe (the other model is TUSS developed at Utrecht in Holland). It also has some features that are unique and hence behaves our consideration and comparison.

All the three models selected (i.e. HIS, CAMPUS and RRPM) used the programmatic approach (i.e. consider programmes) to planning and budgeting.

The models will be examined in terms of their historical growth, their structural similarities and differences as well as for their implementation and use. Models other than CAMPUS, HIS and RRPM will then be surveyed briefly. For the reader interested in pursuing these and other models further, a detailed bibliography is provided.

2. Historical Development of CAMPUS, RRPM and HIS(2)

CAMPUS is an acronym for a "Comprehensive Analytical Methods of a Planning in University Systems". It has its origin in the academic work on simulation in higher education done by Judy and Levine. They developed and now market CAMPUS through their firm, the Systems Research Group (S.R.G.) based

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(1) For another similar survey, see Casasco (1970).

(2) Part of this section appears in Hussain (1973).

in Toronto. It developed CAMPUS V(1) (Judy 1969, Judy Levine & Centner 1970) under a grant of ¾ of a million dollars from the Ford Foundation which was placed in the public domain in 1970. But CAMPUS V was hardly used. Why? Because it was badly documented and because it was very costly - both development and operating costs. The development costs were high because of the large mass of data required by the model including resource data on each activity - a set or subset of a course that requires a unique set of types of resources. These were used for computations that are done mostly by one main programme that led to high operating costs, especially when answering "what if" questions in the simulation mode. Also, most of the data had to be kept in memory requiring a very large computer. For the University of Illinois, this was estimated at 4 million bytes, recently reduced to 300,000 bytes as a result of much reprogramming. Thus CAMPUS V was beyond the reach of almost all institutions except the large and the daring. These included SUNY at Stony Brook and the University of Illinois. The University of Minnesota also implemented it on a pilot basis; /in one school of a university, one state college and one junior college Andrew, 1971 (b)7. But, CAMPUS V did perform an important service to higher education. It demonstrated the feasibility of a comprehensive cost simulation model that could improve decision-making in planning and budgeting. What was needed, however, was a model that made more modest demands on data, equipment and analytical effort so that it could be within the reach of most institutions of higher education.

To achieve such an objective, the United States office of Education funded a proposal for model development by NCHEMS (National Centre of Higher Education Management Systems) at Western Interstate Commission for Higher Education. This product is known as RRPM-1 Resource Requirements Prediction Model.

RRPM 1.2 was the first operational version. It was a modification of the California CSM (Weathersby 1967)(2) made by the staff of NCHEMS and a national task force. It was implemented by eight pilot institutions selected to represent the different types and sizes of institutions in the country. As a result of the pilot testing, further modifications were made and RRPM 1.3 was released in mid 1971 (Hussain, Martin, 1971).

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(1) For a discussion of the development of CAMPUS I-IV see R.W. Judy et al.: "Systems Analysis for Efficient Resource Allocation" in Minter, Lawrence.

(2) For a critique of CSM see Hopkins (1969 and 1971) and for a response to the critique see Andrew /1971 (a)7.

Since RRPM 1.3 was a generalised model, there were other specialised versions planned. Versions 4 and 5 were to be specialised for the community colleges and the state colleges respectively. But instead a sixth version RRPM 1.6 was released. This involved reprogramming and re-arranging of data by discipline rather than function. This decreased core requirements (along with the fact that it does store only non-zero data) in spite of the relaxation of constraints on the dimensions of student programmes and disciplines. This made its use independent of the type of institution using it. It is also conceptually simpler than RRPM 1.3 because it has no space-management capability and has fewer relationships for support costs. It was implemented in 1972 (Huff, 1972) and will be released to the public in early 1973. Both versions 1.3 and 1.6 are now operational and are maintained by NCHEMS.

Meanwhile CAMPUS underwent considerable changes. For its evaluation see Figure 1. It was completely reprogrammed as CAMPUS VI and was made modular. This greatly reduced its operational costs and core requirements. But data are still required at the activity level. However, the input format was changed and documentation was greatly improved making data preparation much easier. CAMPUS VI was reprogrammed as CAMPUS/COLORADO(1) and CAMPUS VIII making them more modular, more flexible in their dimensions, with additions in the costing routines and a better handling of the research sector.

In addition, CAMPUS VII was implemented mainly in Ontario Community Colleges. This version does not require data at the activity level and hence has further reduced core requirements and operational costs. It is designed for institutions requiring data only at the aggregated level of department or above.

Developments in Europe is best seen in the HIS model Dettweiler and Frey [1972 (a)]. HIS stands for the Hochschule Information System, an organisation supported originally in 1969 for 4½ years by the Volkswagen Foundation. Its objective is to develop models and operational systems that will be applicable to all institutions of higher education in Germany.

There are two HIS versions: A and B. Both are alike in their basic computations. The B version is more comprehensive though it lacks the special optimising module of HIS A.

In summary: there are two versions of each of the three families of models worth examining: versions 1.3 and 1.6 for RRPM; Versions VII and VIII for CAMPUS and versions A & B for HIS. But RRPM 1.3, CAMPUS VIII and HIS-B are conceptually the

(1) CAMPUS/COLORADO is a version for CDC equipment and designed to incorporate special features relevant to Colorado.

more comprehensive of their family of models and as such will be the basis of most of the discussion that will follow. Differences in the other operational models, when significant, will be so identified.

3. Basic Logic of Models

The basis logic common to both the RRPM 1.3 and CAMPUS VIII is shown in Figure 1(1). A textual explanation of this figure appears in section 3.1 below. The readers who find Figure 1 self-explanatory can skip section 3.1 without any loss of continuity.

3.1 Basic logic explained

There are some terms that need to be defined because they will occur repeatedly in the discussion to follow. These terms are "credit-hour", "student programme", "programme contact-hour", "activity", "student-credit-hour", "student-contact-hour" and "Full-time-equivalent".

In the United States and Canada, a "credit-hour" is a unit of academic achievement. When a student satisfies the requirements of a course (a presented set of content) which is typically an exam, he then gets accredited to his academic record, a specific amount of credit hours for that course. When he completes a set of courses (which may include electives), and accumulate at least a minimum number of credit-hours, he then gets an academic award such as a diploma or a degree. A specific set of courses (required or electives), each carrying a specific value of credit hours, leading to a specified objective is often referred to as a "student programme". In the above case, each course is a "programme element". But the programme element can be other than a course as occurs in non-academic programmes thus formally, a "programme" can be defined: "to be a collection of programme elements serving a common set of objectives. A programme element is defined to be the lowest level distinct management unit that comprises a collection of resources, technologies, and policies which, through their integrated operation, produce goods or services, i.e. an output, which is of value to the organisation because it contributes to the achievement of an institutional objective ... the programmes of the institution must be organised in such a fashion that management can exercise control over the inputs, the processes, the extent of resource utilisation, and the outputs of each programme." /Gulko (1972: 4-5)/.

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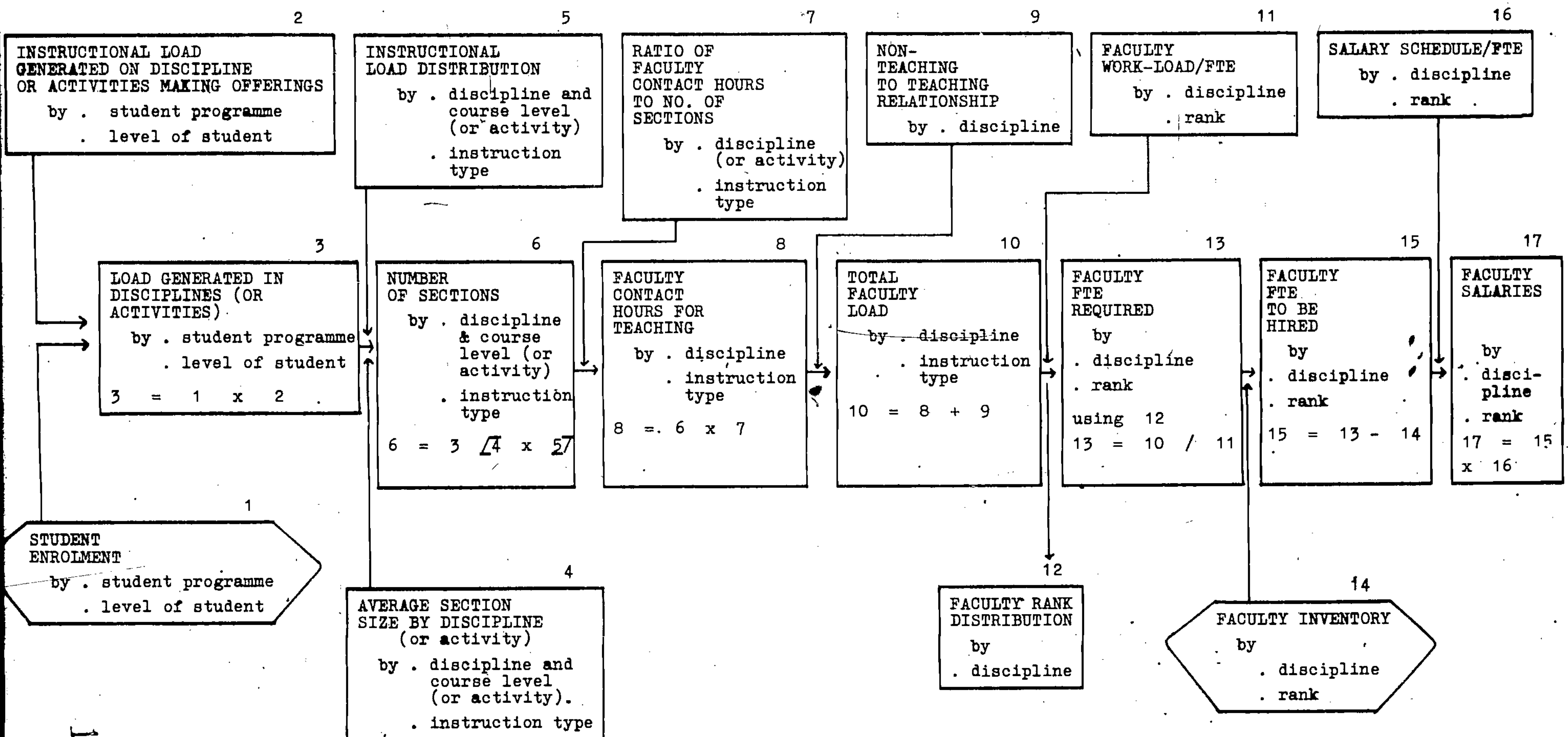
(1) For details on the logic and numerical examples illustrating the logic of CAMPUS, see Hussain (1972). For examples of RRPM 1.2, see Hussain (1971, pp. 9-12, 70-92).

FIGURE 1: BASIC LOGIC FOR CAMPUS, HIS and RRPM



Symbols used

x	x is determined exogneously
xx	xx is determined endegonously
xxx	xxx is a planning control variable

Back to the concept of the credit-hour, typically, the "credit-hour" for a course is equal to the hours that the course needs for a lecture every week. Thus a course having lectures three hours a week has three "credit-hours". Some courses, however, have instruction other than lectures, such as a lab. (laboratory) required for many courses in the Sciences. But typically three hours a week of lab. has only 1 or even 0 credit-hour since the lab. does not typically have the same intellectual content as a lecture. But the meeting-hours a week is an important quantity for planning resources since that determines the resources consumed. It needs to be uniquely identified. It is called "contact-hours" since it represents the physical contact made with resources such as personnel, space and perhaps even equipment.

In many cases, the lecture and the lab. are different courses and there is no problem of identification. In some cases, however, a course may have some lectures and some lab. and then there is in some models the need to identify them separately since they consume different sets of resources. This identification is done in a model like CAMPUS, by referring to each part of the course as an "activity". Thus a course, Physics 101 meets for a 3 hour lecture and a 2 hour lab., but the lab. is worth only 1 credit hour. This course is then identified as as two activities: one lecture activity, call it Physics 101 with 3 credit hours and 3 contact hours; and another activity, call it Physics 101 L, which has 1 credit hour and 2 contact hours. The course Physics 101 has a total of 4 credit hours and 5 contact hours.

The "credit hour" and "contact hour" in itself is not an output of education. However, when one student earns a credit hour it is a measure of output and is referred to as one "student-credit-hour". Simularly when one student makes one contact hour he generates in "student-contact-hour".

In many under-graduate institutions, a student studying full-time takes a total of 15 credit-hour courses per semester or term. This generates 15 student-credit-hours, and is referred to as one full-time-equivalent or F.T.E. Similarly, the term "F.T.E." is used for faculty and staff and enables the aggregation of part-time staff into full-time persons. Thus two half-time persons are 1 F.T.E.; also 3 persons working 1/3 full-time each are 1 F.T.E.

A numerical solution showing samples calculations of the above terms is given in Table 1.

The logic of the basic model as represented in Figure 1 can be re-stated as in Figure 2 where only the main computations are shown and no inputs are identified. This figure could be instructive if read backwards, i.e. starting with the need to

calculate costs of faculty, we need to determine F.T.E. faculty and to determine this we need to calculate the sections needed which in turn requires the determination of the student load. This logic holds true for any level such as an activity or a more aggregate level such as discipline or department. In all cases, the main computation that one must do first is determine the student load, i.e. the number of students in an activity, discipline or department.

Now we return to the detailed flow chart of Figure 1. In it the student load (corresponding to box 3) is determined by multiplying student enrolment (box 1) with the instructional load (box 2). The student enrolment is by student programme which is an academic output such as a degree, diploma or other academic award. Typically it is identified for each level of the student such as 1st year, 2nd year etc. Thus a student programme could be the first year of a chemistry degree.

The instructional load are the courses or activities generated by each student programme. An example of this is shown in Figure 3. In it, student programme 1 generates a 3 contact hour load in discipline 1 or activity 1; a 1 contact hours in discipline 2 or activity 2; and so on for a total contact hour load of 15 hours.

The matrix (or table) identifies the course or activity load "induced" or (generated) and hence is sometimes called the Induced Course Load Matrix. It is however, the load for one student in each student programme. When this load (box 2) is multiplied by the student enrolment in each student programme (box 1) it gives the load generated on disciplines or activities (box 3).

FIGURE 2: AGGREGATE REPRESENTATION OF BASIC MODEL

Determine student load	Determine No. of sections needed for student load calculated, (in last step)	Determine F.T.E. faculty needed for number of sections calculated	Determine costs for F.T.E. faculty calculated

TABLE 1: A PROBLEM AND ITS SOLUTION ON TERMINOLOGY

Problem: Calculate the output of the courses Theology 452 and Chemistry 102 given the following data:

1 F.T.E. student = 15 student credit hours

Theology 452

Meets 3 hours weekly and
3 credit hours
Has 30 students

Chemistry 102

Meets 3 hours weekly for lecture and
4 hours weekly for lab.
with as 2 hours credit (for lab.)
Has 20 students for the lecture
and 15 students for the lab.

Solution

		Theology	Chemistry 102	Chemistry 102 L	Source
1	Credit hours	3	3	2	Given data
2	students	30	20	15	Given data
3	student credit-hours	90	60	30	3 = 1 x 2
4	F.T.E. student	6	4	2	4 = 3 / 15
5	Contact-hour	3	3	4	Given data
6	Student Contact-hour	90	60	60	6 = 2 x 5

Figure 3: AN ICLM (INDUCED COURSE LOAD MATRIX)

	Student Programs			
	No. 1	No. 2		No. n.
Discipline No. 1	3	2		0
Discipline No. 2	1	4		2
Discipline No. m				
Totals for each student program	15	18		12

This is perhaps the most important (computationally) and most difficult (conceptually) part of the model, so let us illustrate this with an example. Let us consider a student enrolment as 200 students in the 1st year Art and 120 students in the 3 year Physics as student programmes 1 and 2. Also, consider, the ICLM as that given in Figure 3. Then the load computations will be as follows:

Student Contact Hours generated by

Student Programme 1

In discipline 1 = No. of students in Student programme 1 x No. of credits in discipline 1

= 200 x 3 = 600

In discipline 2 = 200 x 1 = 200

Student Programme 2

In discipline 1 = 120 x 2 = 240

In discipline 2 = 120 x 4 = 480

The total student contact hours generated in each discipline is now a sum of the load generated by it for each student programme. Thus far:

Discipline 1 = St. Cr. Hrs. by student programme 1 + St. Cr. Hrs. by student programme 2

= 600 + 240 = 840

Discipline 2 = 200 + 480 = 680

This is an illustration of the determination of load generated by disciplines (or activities) (box 3 in Figure 1). It is in student-contact-hours because the units of the ICLM is in contact-hours. If the ICLM is given in credit-hours, then the results of computations as shown above would be student-credit-hours and needs to be converted into student-contact-hours by a ratio of contact hours to credit hours for that discipline or activity.

The next important computation is the determination of the number of sections (box 5). This is done for every discipline or activity and for each instruction type such as lecture, lab., seminar etc. To determine this, we divide the student

load (box 3) by the load distribution for each discipline and instruction type (box 5). This is also divided by the average section size (box 4) which is by each discipline (or activity) and instruction type (the average section size varies with instruction type and is typically larger for lectures and smaller for laboratory classes).

We could check the units of our calculation here. We started with student-contact-hours of faculty load (box 3) and divided it by the contact hours of the ICLM (box 5) to give us units of students. This is divided by the unit of students in the average section size (box 4) gives us a pure number which is the unit of the number of sections (box 6).

The next important computation is the determination of the faculty F.T.E. required (box 13). This is done in three steps. First, we calculate the faculty contact hour generated by discipline and type of instruction (box 8). This is done by multiplying the number of sections (by discipline and course level and instruction type) calculated previously (box 6) by the contact hours for each section concerned (box 7).

Now the second step. We need to calculate faculty load in F.T.E. (box 10). This load is the sum of teaching load calculated previously (box 8) and the non-teaching load given by a teaching to non-teaching relationship (box 9). This is done for each discipline and instruction type.

We are now ready for the last step on the calculation of faculty F.T.E. required by discipline and instruction type (box 13). First the faculty F.T.E. (box 10) is distributed into ranks (e.g. Professor, Assistant Professor etc.) by a rank distribution parameter (box 12) which varies with discipline. This is divided by the work load for each F.T.E. (box 11) given by discipline and rank.

The faculty required by discipline and rank (box 13) is compared with the available inventory (box 14) (determined external to the model) and the difference is the faculty F.T.E. needed (or in surplus) by discipline and rank. We now approach the final calculation: Determination of faculty salaries (box 17). This is done by multiplying the faculty to be hired by rank (box 15) with the faculty salary schedule (box 16) which is also by discipline and rank. This gives us the additional faculty salaries (box 17) by discipline and rank.

3.2 Differences in the Basic Logic

There are many minor differences that do not appear in Figure 1 and have been deleted in order to keep the figure simple. An example is the computation of instructional load. In the RRPM, this is calculated in credit hours and is then

converted to contact hours by a ratio of contact hours to credit hours. This conversion is not done in CAMPUS which has all its activity loadings in contact hours. It is also unnecessary in RRPM if the student loading is done in contact hours to start with.

There are many other such minor differences that will not be discussed. There are, however, two main differences in the logic of RRPM and CAMPUS. They concern the level of detail in instruction loading as well as in planning factors. These will be discussed in turn.

3.2.1 Level of detail

The instructional loading in RRPM is done through an induced course load matrix representing the credit hour load induced by a student major on different levels of courses that are offered by different disciplines. In CAMPUS and HIS, the load induced is in terms of specific courses or activities and are in contact hours. The detailed level of activity does generate a variety of reports that can be very valuable, especially in costing which will be discussed later. It also enables planning at the most elemental academic organisational level and involves all organisational levels in the planning process. However, there is a price that must be paid: the massive detailed data input required at the activity level. This is shown for CAMPUS in Table 2.

In the case of the University of Colorado, using CAMPUS VIII, there are over 2,200 activities and for each activity up to 16 data elements on resource loadings have to be specified. These data must be collected (typically on forms) converted to machine-readable form, stored, processed, and maintained. The maintenance cost (especially on the mix of activities required for each student programme) could be high for institutions where student preferences change or where course requirements change significantly. It is difficult to predict in cases of new student programmes and degrees. It is even difficult to specify the activity mix in order to maintain status quo. This is due to the fact that the student load and activity mix vary not only between semesters but also among types of programmes such as daytime and evening programmes. The mix can be unstable even at the aggregated level of the ICLM; as was experienced by the pilot institutions of RRPM 1.3 (Hussain 1971, pp. 27-28) and other ICLM studies. (Jewett et. al. 1970 and Hussain, Urquardt and Shepherd 1972). These studies show that the greater the disaggregation of the ICLM, the more and instability. This instability will increase as students demand and get more electives and unstructured degree requirements. This will increase the problems of predicting new course mixes and the redistribution of old ones that are dropped.

Table 2: The data elements required for each activity in CAMPUS

- credit hour (per term or seminar)
- contact hour (hours per week)
- type of activity (lecture, lab., seminar etc.)
- Resources required
  - personnel
  - by type (professor, graduate assistant etc.)
  - equipment
  - personnel
  - space
    - type
    - size
- duration in weeks
- identification data
  - name and/or number
  - discipline offering it
- level of activity
- location
- maximum number of sections
- minimum enrolment allowed
- section size policy

3.2.2 Planning variables

The detailed level of data required by CAMPUS occurs throughout the model and is reflected in the planning variables. As an example, consider the determination of the number of sections required. In HIS, RRPM and CAMPUS, the number of sections is determined by dividing the student load by the average section size and using some rule for accounting for the left overs. In CAMPUS, however, the solution is subject to many constraints such as maximum class size, minimum class size and maximum number of sections. This adds to the control and flexibility that the user has but it requires that all these constraints be specified as planning variables (one set for each activity).

For some institutions this choice of planning variables is often unnecessary and this has been recognised in RRPM 1.6 where the faculty F.T.E. can be calculated by an option that uses a weekly credit-hour (or contact-hour) load by level of course thereby eliminating the planning factors of average section size, credit to contact-hour ration, distribution of contact hours, distribution of faculty rank, and average faculty work load by rank.

There are other planning factor differerences between HIS, RRPM and CAMPUS. These are listed in Table 3. One set found in CAMPUS alone enables the "flowing" of faculty between time periods, using rates of turn-over, sabbatical, and promotion policies, contract lengths, and availability periods. CAMPUS maintains a faculty inventory for each time period. It also allows for substitution among ranks within a cost centre but not any substitution among discipline specialities within ranks.

HIS does not have a faculty flow model but has an optimising model for faculty assignment. This is discussed later under optimising models.

4. THE MODEL (continued)

There are three parts of the model other than that shown in Figure 1. One part is a Student Flow Module that goes in front; one part calculates non-teaching salary costs and goes at the end; and is followed by a third part, the costing module. Each will now be discussed.

4.1 The Student Flow Module

This module determines the student enrolment in each student programme at each level of student's academic achievement. It is part of the CAMPUS package and determines the flow of students through the system by using pass-fail rates at each

TABLE 3: SOME PLANNING FACTORS IN CAMPUS, RRPM and HIS

	CAMPUS VIII	RRPM 1.3	HIS
INSTRUCTIONAL			
. Student programmes	. by detailed course/ activity mix	. by mix of credit hours in department/discipline	. by detailed course activity mix
	. resource loading of each activity	. loading of groups of courses at different levels and fields	. resource loading of each activity by
	. space	. space	. space
	. personnel type	. equipment	. personnel
	. time of offering		
	. section size	. section size	. section size
	. average	. average	. average
	. maximum		. maximum
	. minimum		
	. maximum number of sections		
. Faculty	. substitution policy		. assignment: module in version A
	. contract length		
	. turnover rates and hiring policy		
	. sabbatical policy		
	. weekly availability		
	. promotion policy		
	. average salaries by rank	. average salaries by rank	. average salaries by rank
	. rank distribution	. rank distribution	. rank distribution
	. academic level	. academic level	. workload weights
	. workload weights		
	. administrative load		
SPACE	. substitution policies	. (not in RRPM 1.6)	
	. availability	. availability	
	. utilisation		. utilisation
	. type	. type	. type
	. size	. size	. size
	. construction co-efficients	. construction co-efficients	

level, repeat - rates at the same level; drop-put rates at all levels and transfer rates between programmes. (For an excellent survey see Lovell 1971). This is conceptually similar to the Student Flow Model developed by NCHEMS and designed to interface with RRPM (Johnson, 1970). Following the NCHEMS tradition this model was developed by its staff supported by a national task force, tested at selected pilot institutions and implemented successfully (Huff et. al. 1972). HIS has a student flow model but uses only one aggregated transitional value. The NCHEMS student flow model and the one in CAMPUS have much in common: both can be by-passed if desired; both use data on freshmen enrolment and transfers as exogenous variables; and finally, both have problems and issues raised by using the transition matrix. Some of these issues include: the definition of points and student states most suitable for the transition matrix; the calculation, aggregation and stability of transitional probabilities; and the validity of the Markovian assumption for student transitions. These issues are part of the ongoing research and development work being done at NCHEMS. HIS has no cost calculations nor any costing module.

4.2 Non-Salary Costs

Non-salary costs are calculated in both RRPM 1.3 and CAMPUS VIII at the cost centre level. This requires the estimation of both the relationship and the cost co-efficients at the cost centre level. This is no trivial task. At the University of Colorado, the implementation of CAMPUS requires stating 2,800 equations and estimating cost co-efficients. Over 43 variables were used in these relationships, most of them being endogenously determined. (CAMPUS VIII allows up to 130 such variables and 13,000 equations.)

The problem of estimation (and validation which becomes difficult when the accounting system does not keep costs by programmes) can be by-passed by using one cost equation for all support cost at each cost centre. This is done in RRPM 1.6.

4.3 Costing

Both CAMPUS and RRPM calculate costs for academic and support at the programme and sub-programme levels. In addition, in CAMPUS VIII the costs are aggregated by budget function and object category. This facilitates preparing annual line-item budgets for financial control both needed in addition to programme budgets for analysis and decision-making.

Both CAMPUS and RRPM calculate unit cost for student programmes. In addition, CAMPUS calculates the direct cost for each activity. This is aggregated for each activity in the activity mix of each student programme and gives programme costs. In RRPM, the study programme cost is determined as the inner-product of average cost of credit hour by discipline and ICLM.

The average cost figure, however, may result in student programmes using less than average cost-courses in the discipline being over-priced and programmes using higher-than-average-costs being underpriced. This possibility does not occur in CAMPUS because of its detailed activity level costing data.

Indirect costs are allocated to primary programmes (Instruction, Research and Public Service) in both CAMPUS and RRPM 1.3 but not in RRPM 1.6. In CAMPUS, there are options as to some allocation rules: by a specified percentage; in proportion to the direct cost of the receiving categories; or a combination of the above two rules. But in most cases these rules are not logical nor equitable. Such allocation rules are the subject of an NCHEMS study on Cost-Finding Principles (Ziemer et. al. 1971). It has software that will allocate support costs to primary programme and can be used as costing module independently or in conjunction with RRPM(1). It could also be used in a simulation mode to experiment with parameters of allocation. Once the parameters are selected they can then be used for allocation in RRPM 1.3 or 1.6. Most of the parameters can be generated endogenously in RRPM 1.3 and 1.6.

The Cost-Finding Principles project is also expected to suggest procedures for cost exchange among institutions, another of NCHEMS projects (Romney 1972).

Cost allocation raises numerous problems including one of allocating faculty effort between instruction, administration, research and public service. Should this allocation be done by assignment or by actual effort distribution? If the latter, how is faculty effort to be measured? This problem has been popular with institutional researches for over a decade and has not resulted in much agreement. For example, in measuring faculty effort, 24 studies measured hours spent weekly, while 16 used percentage distribution of time, and 4 studies used both (NCHEMS, 1972). This problem and related ones, are the subject of yet another NCHEMS project: The Faculty Activity Analysis (NCHEMS, 1972).

5. Differences between CAMPUS, HIS and RRPM

5.1 Dimensions

Many differences between RRPM, CAMPUS and HIS have been identified above. Other differences are in the dimensions of the model. These are shown in Table 4. Some differences of a technical nature are listed in Table 5. Other main differences concern the Revenue Model, Capital Budget, Output Reports, Capacity module, and Implementation considerations. These are discussed below:

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(1) For its implementation in conjunction with RRPM 1.6, see Huff et. al., (1972) pp. 21-36.

TABLE 4: A COMPARISON OF MAXIMUM DIMENSIONS*

	CAMPUS		RRPM		HIS	
	VII	VIII	1.3	1.6	A	B
Student Programmes	20	350	90	200	6	120
Academic Disciplines or Departments (Teaching Cost Centres)	30	100	90	200	20	110
Non-academic Departments (Non-teaching Cost Centres)	10	25	0	0	0	0
Activities	0	4,000	0	0	200	300
Course Levels	1	(implicit in activity specification)	4	7	(implicit in activity specification)	
Instruction Type	3	9	4	5	5	100
Student Levels	4	8	7	7	14	14
Faculty Ranks	5	10	5	6	12	12
Non-academic Ranks or Classifications	7	150	4	4	0	0
Space Type and Size Ranges						
. academic	8	125	2	0	9	9
. non-academic	10	110	4	0	0	0
Non-personel						
. Resource Types	7	120	3	7	0	0

* Source of data: Van Wijk and Russell (1972) p. 35; K.M. Hussain (1971); Clark, et. al. (1971) p. 6.

TABLE 5: A COMPARISON OF SOME TECHNICAL DATA

	CAMPUS		RRPM		HIS	
	VII	VIII	1.3	1.6	A	B
Programme Language Used	FORTRAN IV	FORTRAN IV	FORTRAN & COBOL	COBOL (ANSI)	FORTRAN	FORTRAN
Equipment Used	Most computers upward of an IBM 1130	IBM CDC	IBM CDC UNIVAC	IBM CDC UNIVAC BORROUGHS	IBM 360	IBM 360
Minimum Core Requirements (thousand bytes)	16	256	128	50 for DOS 65 for OS	more than 256	256
Cost of Software . purchase . lease	$12,500 $ 3,000 + 350/m for 36m	$25,000 $ 6,000 + 700/m for 36m	$50.00	$50.00	0	0
Consulting services for overall project management, training of senior staff and adaption of planning manuals	Varies from $5,000 to $50,000		NCHEMS provides limited training at nominal cost. Other help in implementation is a function of the supply and demand on its staff.			The cost will vary between 0-25,000 and is expected to be largely for the development of an institutional data base

Source of data: SRG (1972) pp. 48, 50, 51 and Van Wijk and Russel (1972), p. 32-35 on CAMPUS; Hussain (1971) on RRPM 1.3 and Clark (1972) p. 31, RRPM 1.6.

5.2 Revenue Module

CAMPUS is the only model with a Revenue Module in which revenue from students is estimated as a function of projected enrolment and tuition rates. Revenue from public funding agencies is calculated by formula which in many cases must be restated and reprogrammed in order to meet local needs. The revenue components can be projected from year to year either by an absolute value or by a given percentage change. The model does not include important components such as financial aids, and portfolio management(1). What it does include is grants, gifts, endowments and special revenues which are treated exogenously instead of making them a function of endogenous variables such as student enrolment number, type of student programmes, etc.

5.3 Capital Budget

Both RRPM 1.3 and CAMPUS VIII calculate the incremental cost of capital expenditures resulting from projected increase in space requirements. To calculate this, however, CAMPUS VIII (not VII) has a greater facilities-planning capability. It "shuffles" rooms around according to given space substitution and utilisation policies; calculates net shortages and surpluses of space by type; calculates space utilisation; and finally maintains inventories of rooms by size and types.

CAMPUS VII calculates the square feet of space and number of stations required for its eighteen space types. RRPM 1.6 has no space management or capital budgeting capability. HIS-A/B, both calculate space needs by room sizes and types.

5.4 Output Reports

All versions of models considered here have sets of output but they vary greatly in number and content. HIS has a minimum set needed for planning but is for a more detailed level than RRPM which is an aggregated model. CAMPUS VIII, in comparison has a detailed and by far the most comprehensive set of reports. The output is particularly good for space management and on administrative indices on loading, costing and utilisation. It has an extensive set of reports on the validity of data that is valuable in data generation.

No model prepares plottings as part of its computer output but data from the tables can readily be plotted manually. This is done for CAMPUS and is shown as samples in Figures 4 to 7(2).

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(1) For one research formulation of this, see T.W. Ruefli (1970).

(2) These figures are taken from a run of CAMPUS. However, the data has been slightly altered and some details of the source purposely suppressed in order to maintain confidentiality of the data.

Figure 4: PROGRAM CATEGORY STUDENT CONTACT HOUR COSTS BY BUDGET FUNCTION 1972

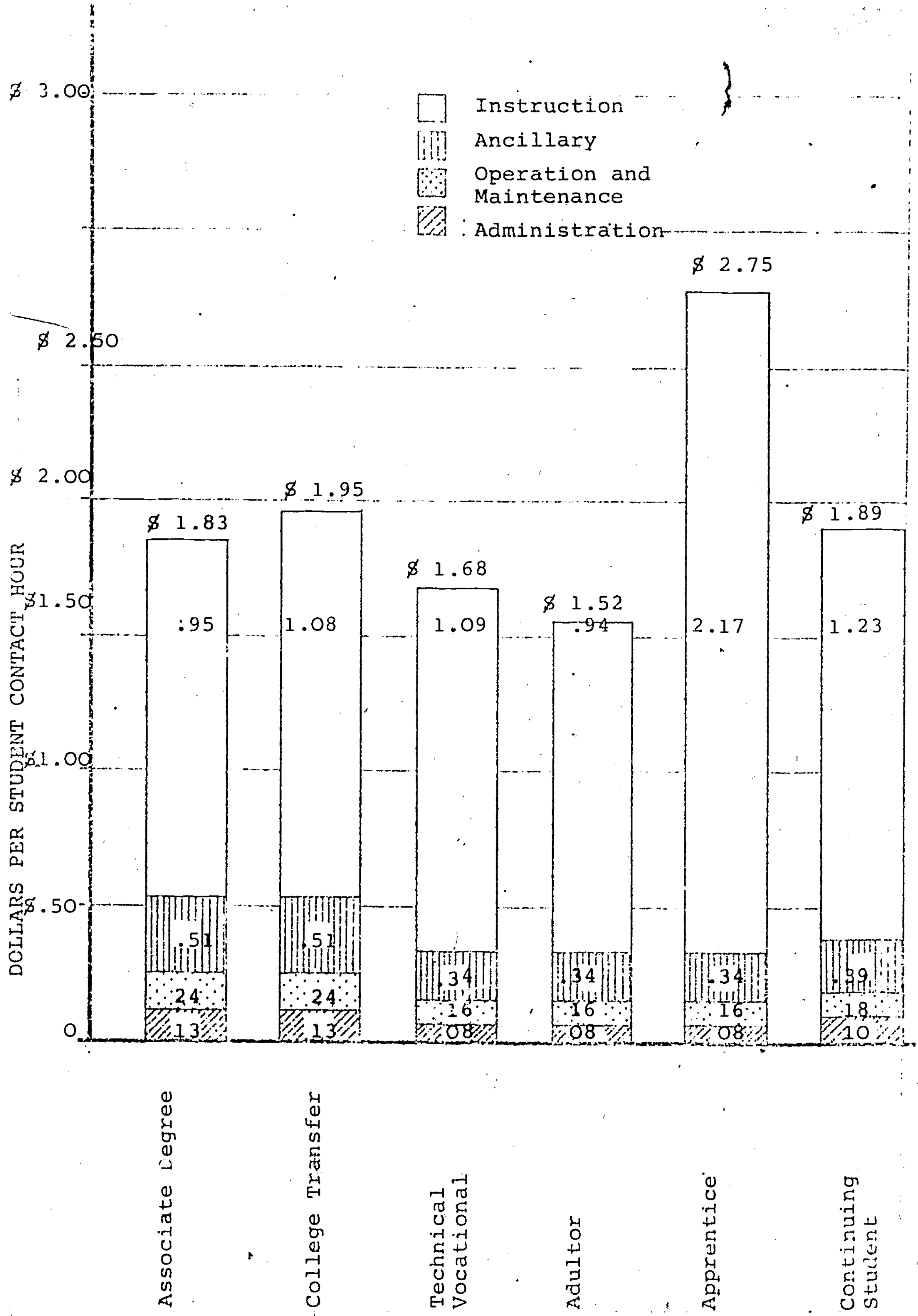


FIGURE 5

TOTAL TEACHING SALARIES PER STUDENT CONTACT HOUR
BY ACADEMIC DIVISION
1972 - 1976

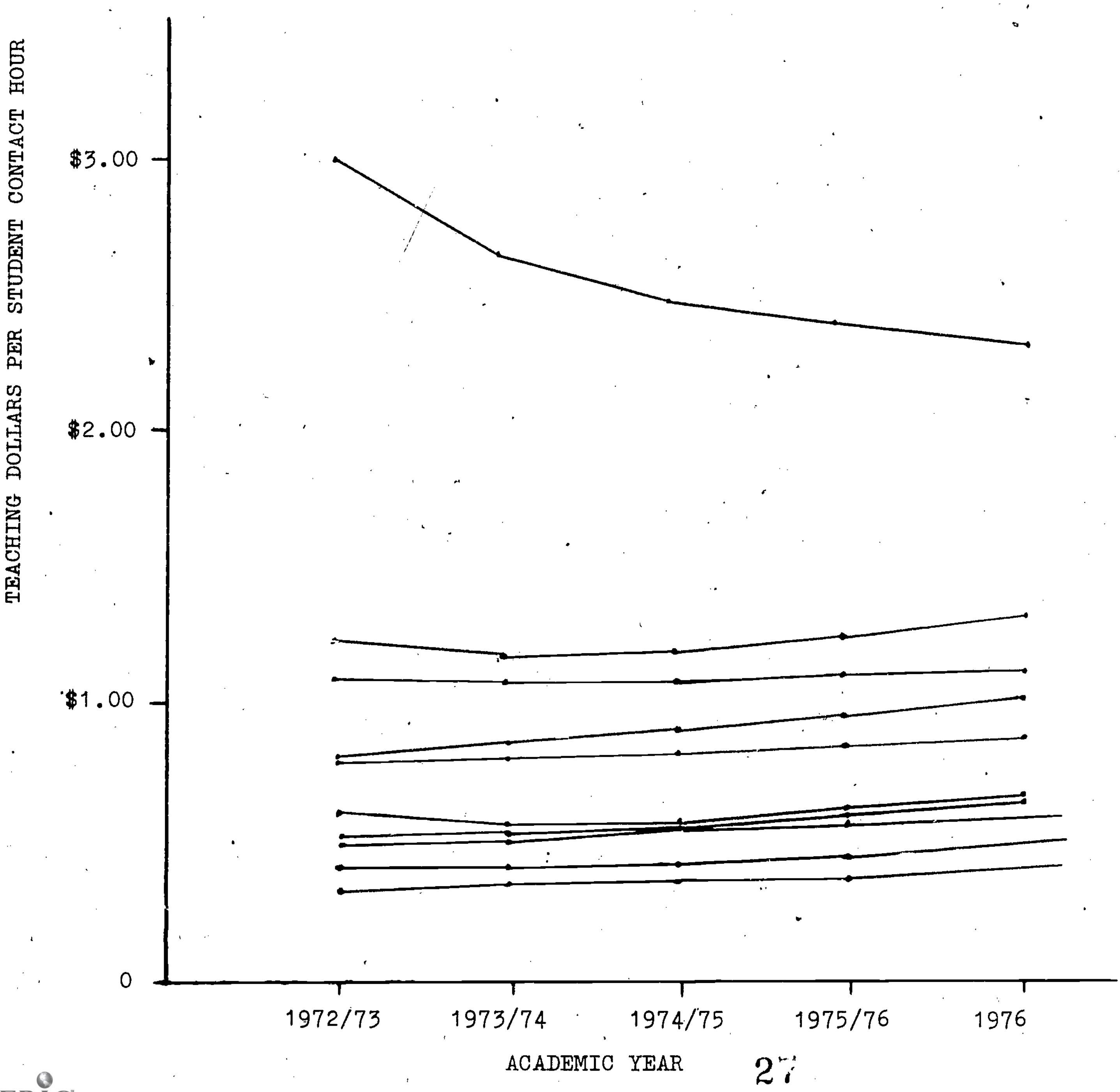


Figure 6

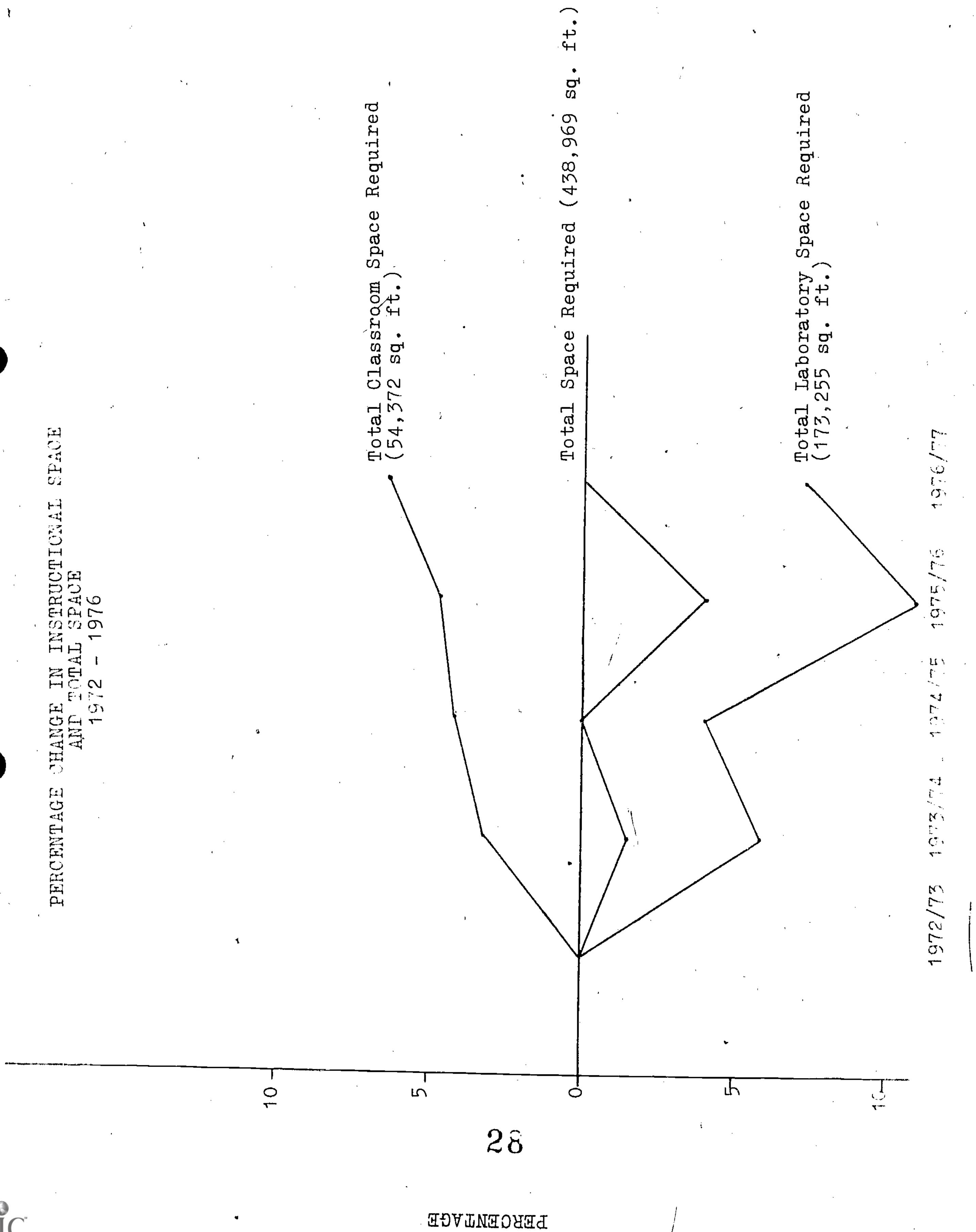
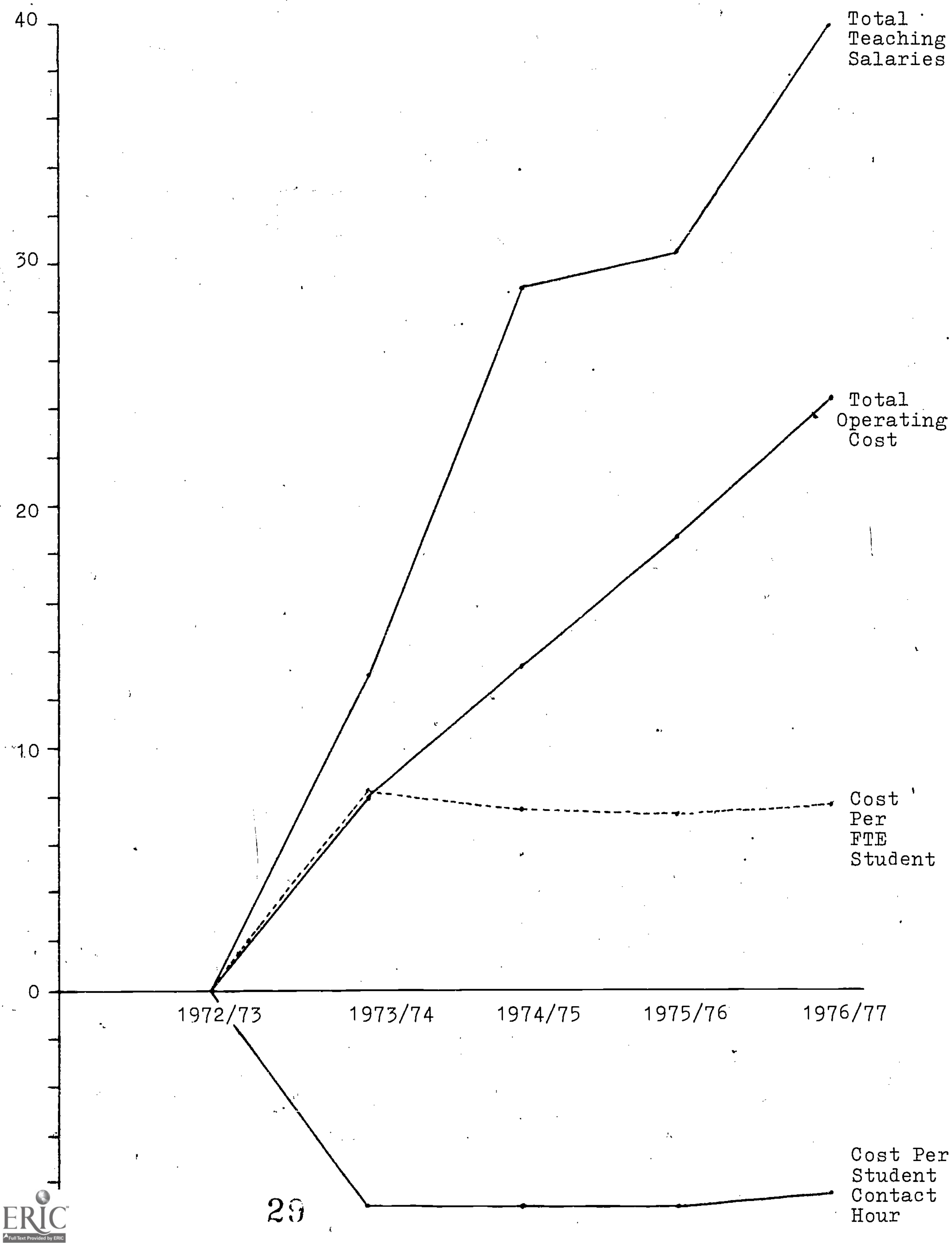

PERCENTAGE CHANGE IN INSTRUCTIONAL SPACE
AND TOTAL SPACE
1972 - 1976
Total Classroom Space Required
(54,372 sq. ft.)
Total Space Required (438,969 sq. ft.)
Total Laboratory Space Required
(173,255 sq. ft.)
1972/73
1973/74
1974/75
1975/76
1976/77
10
5
0
5
10
PERCENTAGE

FIGURE 7: CUMULATIVE PERCENTAGE INCREASE IN ADMINISTRATION COLLEGE INDICES 1972 - 1976



RRPM 1.3 also has a unique report. It identifies on one page the results of ten sets of changes made in the "what if" experimentation mode(1). The display of results facilitates an analysis of incremental changes and of sensitivity analysis. For such experimentation the user may make blanket changes by percentage or an absolute value in addition to replacing one or more values. CAMPUS and RRPM 1.6 allow only a percentage blanket change and only for a select set of variables.

RRPM 1.3 has a TRACER - TRAINER routine that "traces" all the intermediate output for any one selected discipline. This is useful not only in training a user on how the model handles his data but also in debugging and in validating the model.

An institutional implementation of RRPM 1.3 has the TRACER on a terminal in the programmed instructional mode along with routines to help the uninitiated user. CAMPUS VIII also has a CAI package. It has an interactive prompter which is especially helpful to the user.

Both RRPM and CAMPUS can answer "what-if" type questions that would help the educational administrator. Some of these are:

A. <u>Staffing Changes</u>

- What if the current staffing ratio of support personnel was increased or decreased by 10 per cent?
- What if the average faculty load in a given college was increased to the average of other colleges?
- What if there was an X per cent raise in faculty salaries and a Y per cent raise in non-faculty salaries?
- What if a change is made in the mix of instructional faculty? (Such changes might be in the ratio of full to assistant professors or the use of graduate assistants in recitations instead of assistant professors.)
- What if a change is made in instructional techniques? e.g., substitute capital (equipment) for labour (faculty).

(1) For a sample see Gulko and Hussain (1971) pp. 30-33.

B. Curriculum Changes (Note: A curriculum change typically requires extensive modifications to other curricula).

- What if a new degree programme was to be added and another were to be dropped?

- What if a service discipline (not offering a degree programme) was added?

- What would be the effect on the math service courses if the junior college transfer sector was to increase by 60 per cent?

- What would be the effect on the English department if the English Composition requirements for math majors were removed?

C. Admissions Policy

- What if a specific change is made in the mix of students either by degree programme or by level or both?

- What if the institution limits its admission in various fields three years from now?

- What if the enrolment for a given level of students was eliminated or initiated?

D. Other

- What if there were additions or deletions to existing programmes in Research and Public Service?

- What if one or more of the factors in space or construction were to change?

- What if the cost relationships for travel, equipment and supply were to be altered?

- What if the library costs per student were increased by 10 per cent?

The resource implications of questions like some of the above may be answered only to a limited degree. Clearly, there are other subjective implications which reflect upon the quality of operations such as effects on students contributions to society, and impact on faculty values. The state-of-the-art in modeling has not advanced sufficiently to deal in a quantitative manner with this aspect of planning and programmating changes. However, the ability to compute rapidly the resource implications of alternatives will lead, hopefully, to a more ordered and structured consideration of the subjective aspects of higher education.

One case where RRPM 1.2 was actually used in decision-making by asking the "what-if" question is illustrated in Figure 22. In this case, the administrator asked for the trade-off between faculty load and class size given a fixed salary of $1,100,000. A set of pairs of values for faculty load and class size were generated and is shown in Figure 8. (The points are joined for the illustration realising that the curve is not continuous). Once an area of interest or feasibility is identified, then more points on the same budget line could be generated. Similarly other sets of trade-offs are calculated for varying budget lines and these are also shown in Figure 8. Such curves were very valuable in graphically demonstrating the trade-offs involved.

5.5 Capacity Module

HIS - A has one module that no other model has. It calculates the students enrolment given its capacity for faculty (by rank and within disciplines). In other words after it calculates the needed capacity given students, it calculates the students that can be taught given capacity (in disciplines and ranks where there are excesses).

The flow of this model is shown in Figure 9. In it we reproduce the start and end of part of the basic model (as discussed earlier in Figure 7). The capacity module starts with the calculation of Faculty F.T.E. required by each rank within each discipline.

In cases where there is a surplus of faculty, the utilisation of faculty is calculated by a specific algorithm (box 15a in Figure 9). This utilisation is then compared with desired utilisation levels as stated by policy parameters (box 15b). If the comparison (box 18) shows that the utilisation is less than the desired utilisation, then the YES exit of box 18 leads to box 19 where the students enrolment is increased. The model is recalculated until the utilisation is equal or greater than the desired level. Then the NO exit of box 18 leads to printing of the new value of enrolment (box 20) and the calculations continue to box 17 of Figure 1.

This module is of less interest at the moment to universities within the United States because they do not have the same problem of under capacity that exists in West Germany and other countries in Europe. In any event, the model should be of interest to model builders because of the "clever" algorithm of iterating the approaches a minimum number of iterations.

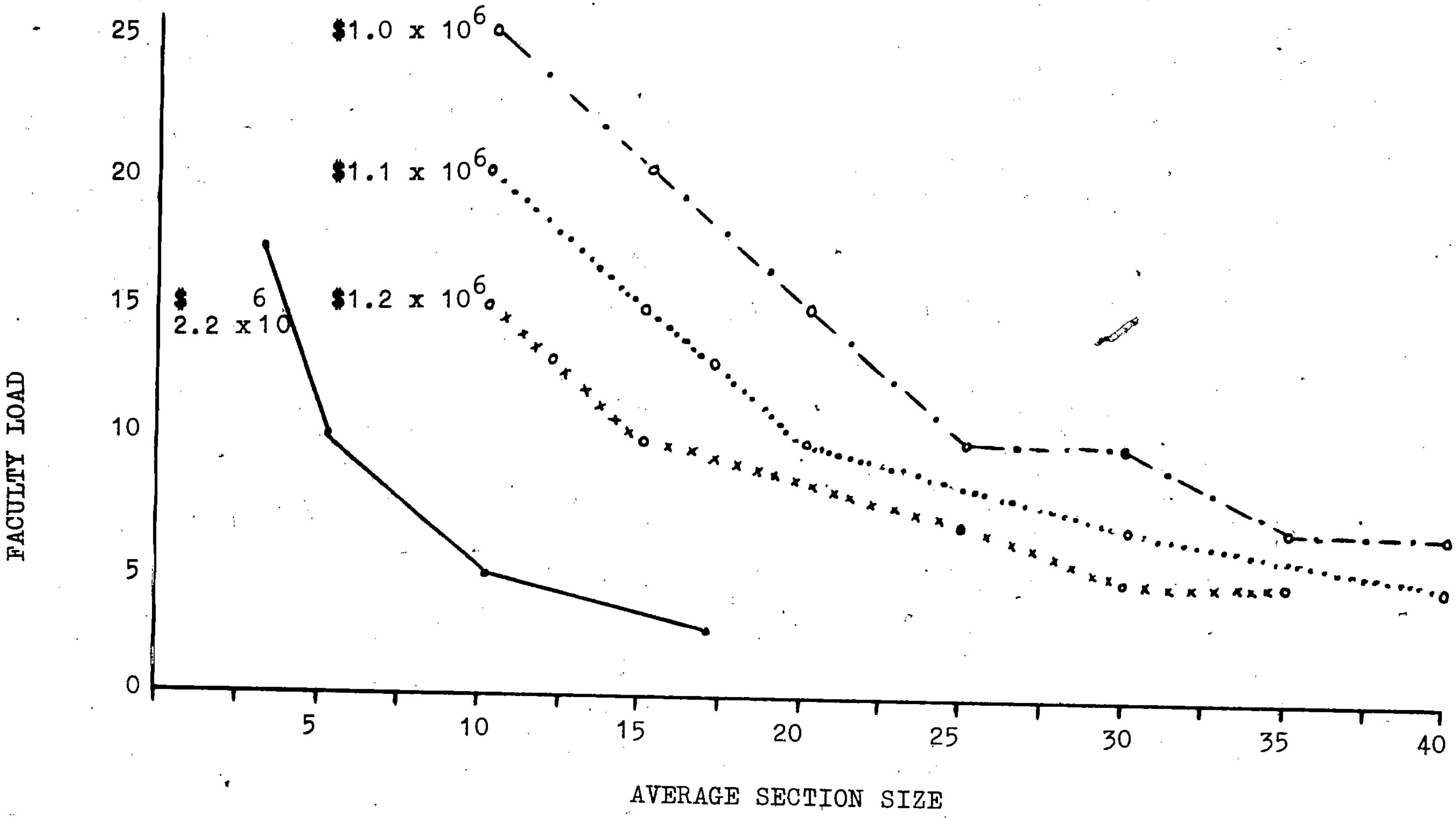
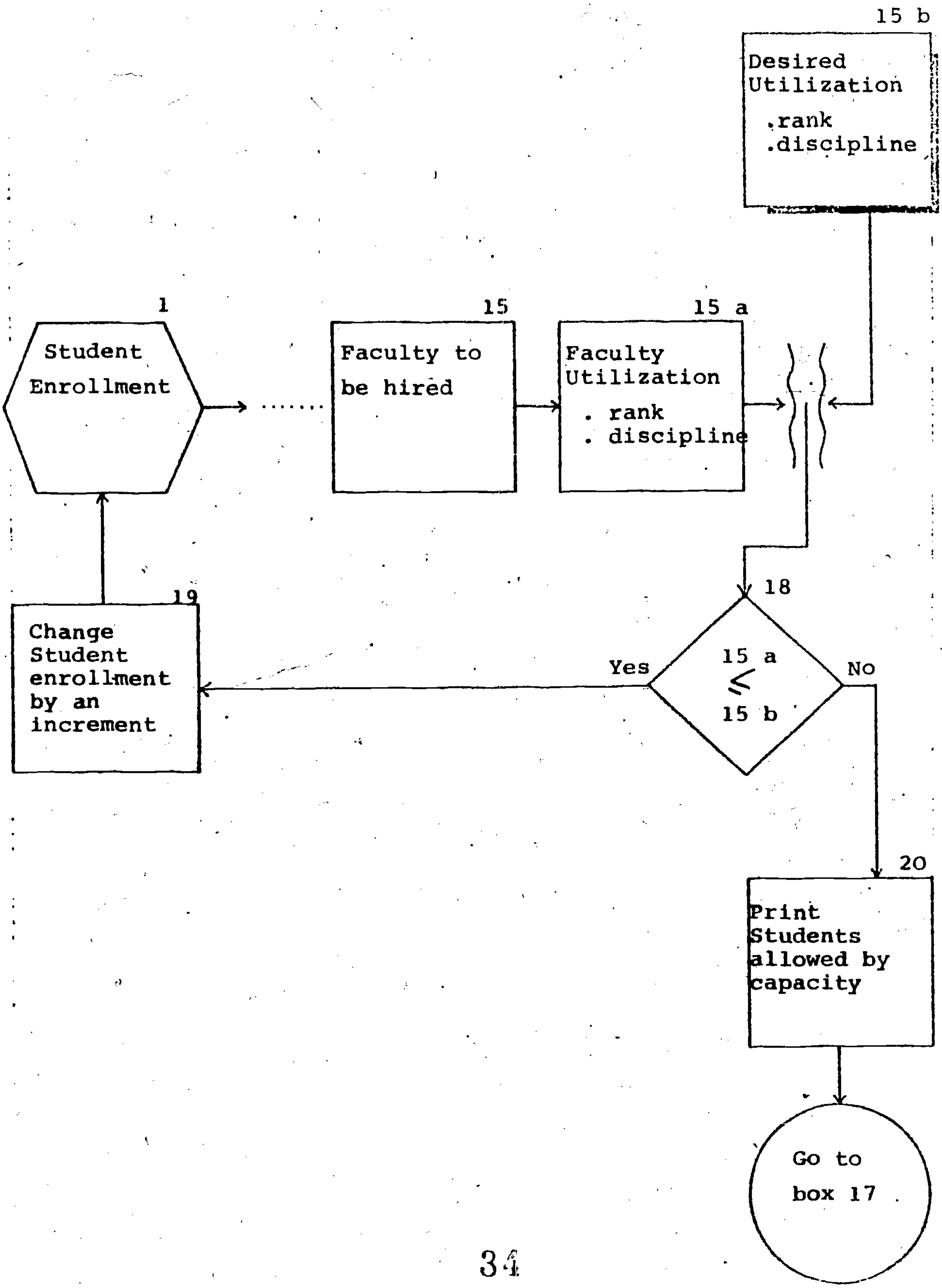


FIGURE 8: TRADE OFFS BETWEEN FACULTY-LOAD AND AVERAGE SECTION SIZES FOR DIFFERENT BUDGET LINES

Figure 9: CAPACITY MODULE



5.6 Cost of Development of Model

The one time cost of development is difficult to ascertain for CAMPUS since it is now the property of a firm and such data is not available. Some data are available, however, for the development of RRPM and this concerns the cost of pilot implementation. This varied with all the eight institutions reflecting the different environment and the status of data-base. Some averages and ranges are presented in Table 6 and give some clues to the magnitudes involved in the pilot implementation of a new model. It must be emphasized that these figures include much experimentation and development and is much higher than the cost of implementing an existing version of RRPM.

5.7 Cost of Implementation

In evaluating models, one should look at their cost effectiveness ratios. The effectiveness of a planning model, however, cannot all be quantified. Its implicit value could, however, be compared to costs and a judgment could then be made as to whether or not it is worth the cost.

In calculating the costs, one must differentiate between development and operating costs to the institution. Development costs include the cost of software discussed in Table 3. Other development costs include costs of changing the model to meet institutional needs, validating the changes, data generation and training. Typically, the largest component is that of data preparation. This, in turn, depends largely upon the type and quantity of data required. This could be compared for actual implementations of the model to be compared, but such comparisons invite suspicion since institutions to be compared are often different in structure and complexity. To overcome this problem, one could compare the data generation problem for each of the models. This is done for four types of institutions whose institutional characteristics are compared in Table 7. Their data generation problems are compared in Table 8.

Data generation is important not only in estimating development costs, but also in estimating operational costs. Such costs increase greatly when data elements are updated annually. In a cost study done for CSM (the conceptual basis for RRPM), Hopkins found that the annual updating of the data base more than doubles the annual operating costs of maintaining the model (Hopkins 1969). Maintenance of the data base is necessary in order to reflect the changing values of many of the parameters in the model. In a study of some departments in Berkeley, a study by Bremenan found that the faculty requirement co-efficients vary as much as 200 per cent from one year to the next (Bremenan 1969).

TABLE 6: COST OF DEVELOPING RRPM BY PILOT INSTITUTIONS(*)

	Unit	Average	Range
Direct cost	$	27,616	9,510 - 43,000
Indirect cost	$	26,961	12,174 - 62,187
Manpower	man year	0	
. Management	man months	2,9	1 - 7
. Analyst	man months	11,8	2,7 - 19
. Programmer	man months	12,4	3 - 41
. Other	man months	3,2	0 - 10

Note: The lapse time from the data of funding to the completed implementation of the first pilot study was 37 months.

(*) Source of data: Hussain and Martin (1971) pp. 14-17.

Changes to parameters also result during experimentation when making simulation runs. This increases the operational cost (the cost of each simulation run is shown in Table 8, which is a necessary cost if one wants to investigate the consequences of possible changes).

Other components of operational costs results from the need for continuing analysis of output, and the need for training the user. These components are very important aspects of implementation and are not sufficiently recognised. The estimate for this effort is also shown in Table 8. It will vary with institutions and is a function of their planning experience; the support that they can get from other departments such as the Computer Centre; the number or nature of modifications to the model initiated by the user and the Computing Centre; the extent of the use of the model; and finally the thoroughness with which the task is performed.

In Table 8, the figures for CAMPUS VIII are based on empirical data. The figures on the remaining models were estimated by the writer and colleagues who are as knowledgeable about the institution and very knowledgeable about implementation of the models concerned. The figures were then checked against published data on implementation. Unfortunately there are not much data on the implementation of RRPM 1.6 and CAMPUS VII since these are relatively new models and have few implementations. The number of implementation of these and other models are shown in Table 9.

TABLE 7: CHARACTERISTICS OF INSTITUTIONS COMPARED (FOR 1971-72)

	Multi-Campus University		State College	Community college
	Main Campus	Branch Campus		
Student F.T.E. (Average for Year)	18,632 (Semester)	2,283 (Semester)	5,284 (Quarter)	2,400 (Quarter)
Highest Degree Offered	Ph.D.	Masters	Masters	Associate
Student Programmes	275	26	65	58
Cost Centres - Academic	53	12	46	11
Cost Centres - Non-academic	47	9	20	21
Academic Activities	2,200	724	1,200	244
Instruction Types	9	6	4	2
Student Levels	8	6	6	1
Course Levels	5	5	5	1
Faculty Rank	9	5	8	1
Non-Academic Rank	38	15	33	5
Space Types	70	29	15	15
Other Resource Categories	19	10	10	3
Other Resource Sub-categories	56	31	4	7

Table: 8 Comparison of Cost-related Elements

	Multi-campus University								State College				Community College			
	Main Campus				Branch Campus											
	CAMPUS		RRPM		CAMPUS		RRPM		CAMPUS		RRPM		CAMPUS		RRPM	
	VII	VIII	1.3	1.6	VII	VIII	1.3	1.6	VII	VIII	1.3	1.6	VII	VIII	1.3	1.6
Data Elements in ICLM (in 000's)	18	1815	18	18	0,3	19	0,3	0.3	3	78	3	3	0,6	14	0,6	0,6
Regression Equations for non-teaching salary costs		2800	300			630				2400				600		
Development Costs * in 000's of $	12	80	35	9	4	20	25	5	10	26,4	32	7	4	20,7	24	6
Run Cost in $ ** for one complete set of reports	3	500	.	3	2	200		2	2	300		3	2	200		2
Maintenance ** Cost in Analyst FTE	1,0	3.0	1,5	1.0	0,25	0,5	0,75	0,5	0,75		1,0	0,5	0,75	0,5	0,5	0,25

* These costs do not include the cost of administrators working on the model, cost of software, consulting or overhead. Some of it may be sunk cost.

** These costs need not be out-of-pocket costs, especially if the model becomes part of the 'normal' operations of the institution.

TABLE 9: NUMBER OF IMPLEMENTATIONS(a)

CAMPUS	
Versions V, VI and VIII	42
VII	8
HELP/PLANTRAN	50
HIS-Versions (a) and (b)	2
RRPM	
Version 1.3	70(b)
Version 1.6	175(b)
CEM(c)	115(b)
SEARCH	8
TUSS	/

(a) Source of Data: For CAMPUS, the data came from SRG, (1972) p. 47 and for RRPM and CEM the data came from the Office of NCHEMS at WICHE in September 1973. Data for PLANTRAN and SEARCH come from Van Wijk and Russel (1972).

(b) These figures are for programmes distributed not necessarily all implemented. NCHEMS does not implement or control the use of its software and hence has no way of knowing exactly how many of its programmes have actually been implemented.

(c) CEM is a training version of RRPM which after being used for training is also being used for planning in the operational mode. It is conceptionally similar to RRPM 1.3, has smaller dimensions than either 1.3 or 1.6, and has been implemented only on IBM equipment.

6. Other Planning Models

Table 8 also shows the implementation for HELP/PLANTRAN as well as CAP: SC/SEARCH and TUSS, since they are also resource allocation models with more than one application each. These models will be discussed briefly below. Also to be discussed is the TUSS model, the second most implemented model in Europe. However, before doing so, mention must be made of other specialised models. These include the TULANE University model (Firmin et. al. 1967); a model for the University of Washington (Koski 1968) FACSISM and RCM for the United States Air Force Academy (Van Wijk and Russel, 1972, and Allison 1970), GUS, the Generalised University Simulation implemented at the University of Texas (Ruefli 1970) and CAMPUS/HEALTH, a special version of CAMPUS for medical institutions (Wilson R., et. al. 1969). Studies that have made conceptional contributions to resource allocation modelling include the model for Michigan State University (Koenig, et. al., 1968 and 1969); the work on a

State-Space Model (Zemach, 1968), the resource model (one of the few with a faculty flow module) by Hammer-Jesperson (1972) in Copenhagen and the S.O.M. model developed by O.E.C.D. (1970). There are also numerous studies in Europe that relate to planning and capacity models. They include Bessai et. al. (1969); Braun, Hammer and Schmid (1969); Casper et. al. (1969); Dietze (1969); Goossens (1971); Kings-Finkenstaedt (1969); Menges and Elstermann (1970); and O.E.C.D. [1969, (a), (b) and (c)].

6.1 CAP:SC/SEARCH

CAP:SC is an acronym for "Computer Assisted Planning for Small Colleges". It has been superceeded by SEARCH which stands for "System for Exploring Alternative Resource Commitments in Higher Education" (Keane and Daniel, 1970, and Struve, 1972). These models were developed by the consulting firm Peat, Marwick, Mitchell & Co. They are operated in the batch mode.

This family of models is very similar to the basic computations as shown in Figure 1, but is basically more concerned with the policy level rather than the operational level. It also considers many additional decision variables such as library stations, volumes to be purchased in the library and dormitory space. It also has its own student and faculty flow modules.

The important distinction between CAP:SC/SEARCH and RRPM or CAMPUS is, that CAP:SC/SEARCH is specially concerned with financial statement of a small private institution. It therefore includes consideration of endowment and current fund projections as well as gift income and interest rates.

The interactive mode of SEARCH encourages its use to ask "what-if" type questions. The user has the option of requesting results either for one year or for multiple years.

6.2 HELP/PLANTRAN

HELP stands for "Higher Education Long-range Planning" (Sutterfield 1971). It was followed by PLANTRAN, an abbreviation for "PLANning and TRANslation" and refers to the "translation of plans into a computerised system" (McKelvey, 1970). These models were developed by Midwest Research Institute. The model is operated in the batch mode and is accessed by over 50 institutions (Van Wijk and Russell, 1972, p. 26).

The models are essentially budget simulators. They calculate each line item for cost or resources for each year of the planning horizon with no limit on the number of line items. The line items (and their projections) can be stated or instead projection equations are stated and then the model performs the projections. Any line item for future planning

year could be changed (increased or decreased) by an absolute amount, a percentage amount or changed to a stated ceiling value. The line items can be calculated for different levels of aggregation including the course level.

6.3 TUSS

TUSS stands for "Total University Simulation Systems". As yet it is not a total system but has been implemented at one college in the University of Utrecht in Holland. It is the only model discussed thus far that has been developed entirely by institutional effort and funds.

TUSS like HIS-A/B is a resource model not a cost or costing model. In basic computations and in the planning output(1) they are very alike. It is interesting that these two models were developed at towns that are only 6 hours driving distance away and yet they were developed independently and without much help or communication between them.

TUSS has not one but three student flow model options (aggregated transitions, disaggregated transitions and another model developed at the university). It has no faculty flow but weights faculty load, not only for instruction and not instruction but also research.

TUSS has zero inventory like RRPM and makes no comparisons of resources needs and availability as does CAMPUS and HIS. But TUSS is well designed for simulation and for asking WHAT-IF questions. For that it has an extensive and well documented sub-system that enables changes to all planning factors allowing many options in the types of changes to be made.

Finally, like RRPM, TUSS has its own game used for training. It is a simpler construction of TUSS and has been used not only to train faculty but also students in the use and working of the model.

SUMMARY AND CONCLUSIONS

In comparing the class of operational models for resource allocation one can identify RRPM, CAMPUS and HIS as the three most interesting of them, the models that operate at the discipline or department level are RRPM 1.3, RRPM 1.6 and CAMPUS VII. Among these, RRPM 1.6 is conceptually the simplest and least comprehensive. It is also the cheapest in both development and operational costs. RRPM 1.3 is slightly less

(1) TUSS has a very rich set of analytical output and also output useful for operational management.

comprehensive than CAMPUS VII but is cheaper to develop largely because of its negligible costs for its software. It does, however, require more computer core memory than does CAMPUS VII or RRPM 1.6.

HIS - versions A and B, and CAMPUS VIII are the more detailed both in the input required and the output produced. It is, therefore, more suitable for decision-making at the detailed and departmental level (for budget or curriculum planning at the course level) but the price of such capability is larger core requirements and higher costs of both development and operations.

HIS-A/B are less comprehensive than RRPM or CAMPUS because they are resource models and limited to only teaching personnel and space. But in performing the academic calculations it is the most sophisticated especially in the weighting of faculty load. It also has the optimal faculty assignment and capacity module (calculating students given personnel capacity in disciplines) that are unique to the HIS-A.

CAMPUS VIII is by far the most comprehensive in terms of detail, scope and the choice of planning variables. It also has the most comprehensive set of output reports that are useful not only in planning and budgeting but also for control and operational management.

The differences between the model developed in Europe (HIS-A/B and TUSS) and those developed in the United States and Canada (RRPM and CAMPUS) can be illustrated in Figure 10. The European models are very similar in basic logic to the American models but are confined to teaching space and personnel resources boxes 1-5 and part of 6 (not all resources like travel, supplies, etc.), 7 and 8. They are not as are RRPM and CAMPUS with the non-academic sector, capital and operating budget, cost and costing (boxes 9-15).

Some of the differences mentioned above and others are summarised in a tabular form in Table 10 to facilitate comparisons.

The models of resource allocation that were discussed have some common characteristics: they are cost models and not cost-benefit models; they are simulation models not optimising models; they have mostly linear equations for calculating their non-salary costs (when this is done) and thus ignore discontinuities; the models do not predict the number of new entrants to the institution nor do they relate it to manpower requirements; and finally, all are deterministic models (except for the probability matrix used in the student flow module).

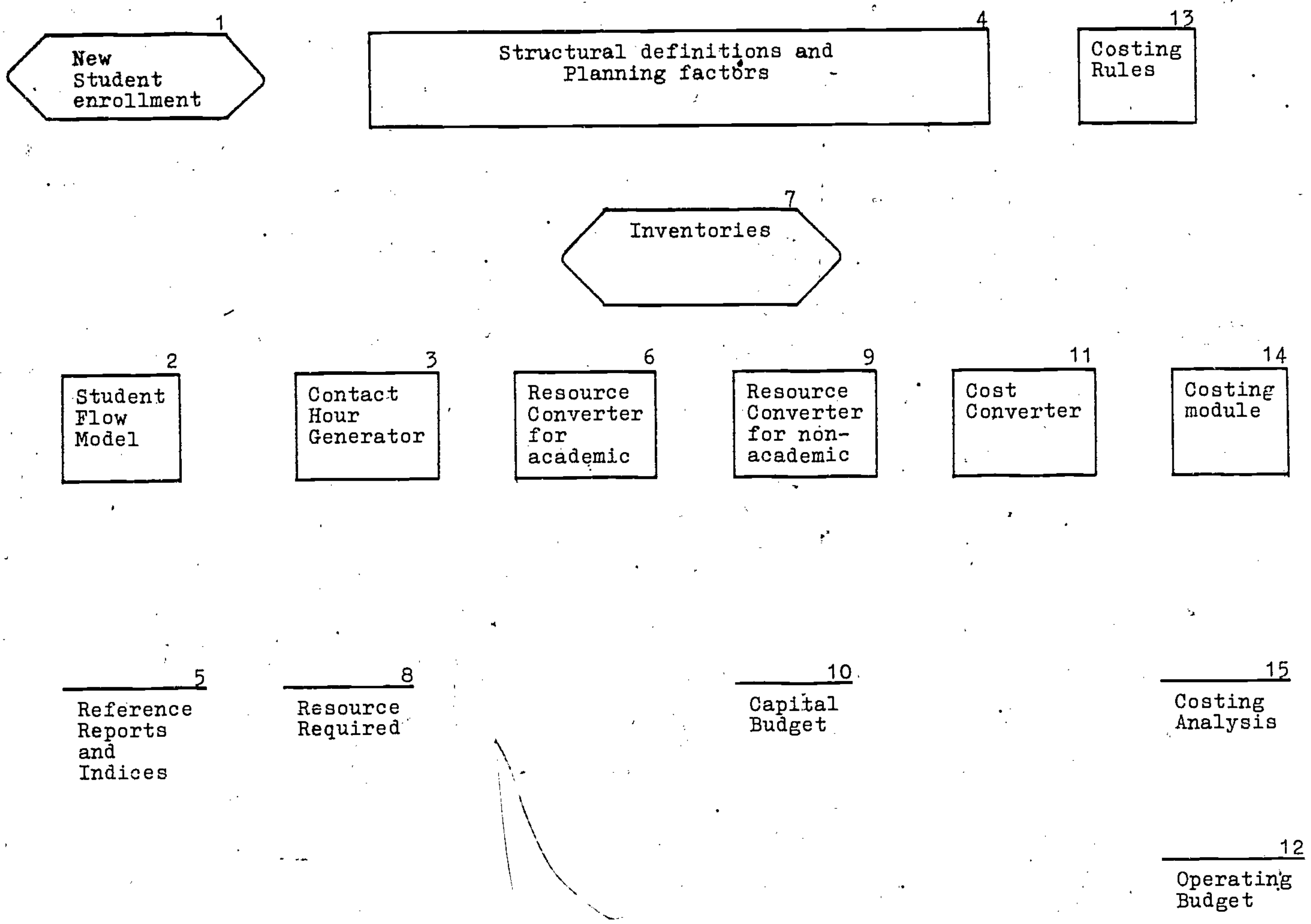
From the viewpoint of helping the user implement and use the model, none of the models provide help in formulating the support (non-salary) cost equations nor in calculating the cost

co-efficients. Also, no help is provided in studying and improving the stability of parameters especially the ICLM. Some work has been done with CAMPUS and RRPM 1.3 in using terminals but not enough work done on the economics and feasibility of using the model to respond to "what if" questions in the on-line-real-time mode. Also, no help is provided to the user in searching through the very large set of permutations of possible alternative strategies (both before running the model and after the model is run). Search routines for identifying "promising" and near optimal strategies will greatly help the user. Even the current output will help the user if it were packaged with graphics that show "trends" and "gradients" rather than a mass of numbers of a sheet of paper. Reports should be designed that also help in management by exception by identifying information and variations that exceed allowable levels. Finally, the models do not enable the user to calculate trade-offs directly. For example, if one wishes to find the trade-offs between average section size and faculty load which keep the cost constant, one has to guess at pairs of values, calculate the costs, and then plot an iso-cost curve (as done in Figure 8). This can be both costly in computer time and slow in response time.

TABLE 10: DIFFERENCES BETWEEN CAMPUS, HIS AND RRPM

	CAMPUS VIII	HIS - B	RRPM 1.3
Cost and Costing Model	Yes	No	Yes
Level of Detail	course/activity	course/activity	Discipline
Non-academic sector included	Yes	No	Yes
Non-teaching duties weighted	Yes	Yes	No
Student flow transitions	Disaggregated	Aggregated	Disaggregated
Faculty	Flow	Optimal Assignment (in version A)	None
Special modules	Revenue	Capacity	Training Game
Planning variable	Many	Few	Few
Output	Excellent	Minimum	Adequate
Computer core required	256,000	256,000	128,000
Development cost	$25,000 + consulting	0 + consulting	$50

FIGURE 10: COMPONENTS OF A COMPREHENSIVE PLANNING MODEL



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